# Computer and Mathematical Occupations

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## Occupations Included in this Reprint

# Actuaries

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**Significant Points**

- A strong background in mathematics is essential.
- About 7 out of 10 actuaries are employed in the insurance industry.
- This small occupation generates relatively few job openings; the fastest employment growth is expected in the computer and data processing services, health services, and management and actuarial consulting industries.

**Nature of the Work**

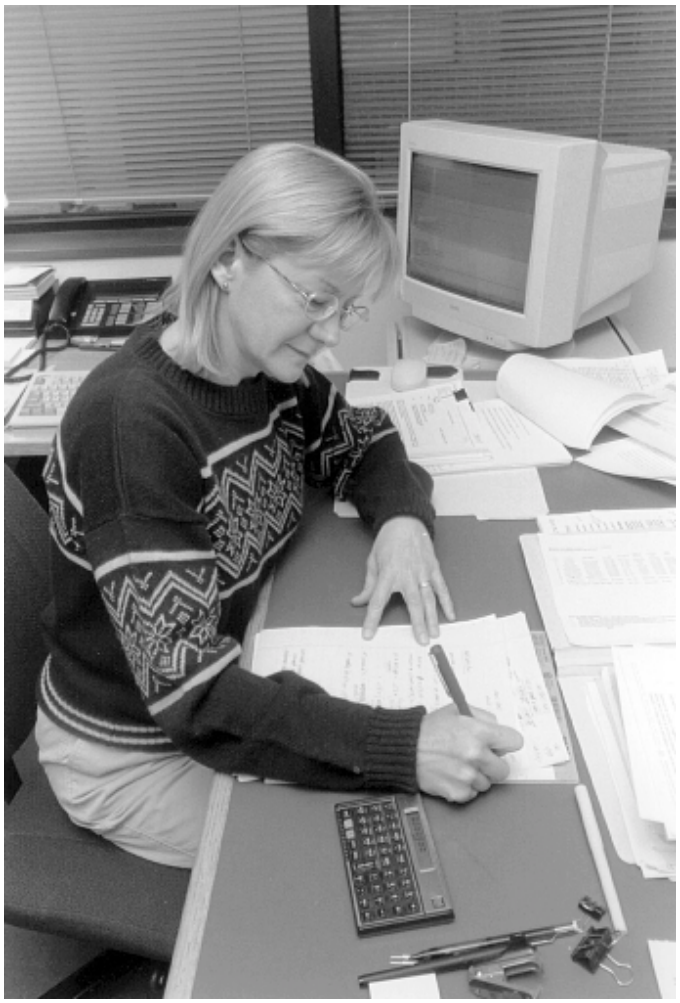
Actuaries are essential employees because they determine future risk, make price decisions, and formulate investment strategies. Some actuaries also design insurance, financial, and pension plans and ensure that these plans are maintained on a sound financial basis. Most actuaries specialize in life and health or property and casualty insurance; others work primarily in finance or employee benefits. Some use a broad knowledge of business and mathematics in investment, risk classification, or pension planning.

Regardless of specialty, actuaries assemble and analyze data to estimate probabilities of an event taking place, such as death, sickness, injury, disability, or property loss. They also address financial questions, including those involving the level of pension contributions required to produce a certain retirement income level or how a company should invest resources to maximize return on investment in light of potential risk. Moreover, actuaries may help determine company policy and sometimes explain complex technical matters to company executives, government officials, shareholders, policyholders, or the public in general. They may testify before public agencies on proposed legislation affecting their businesses or explain changes in contract provisions to customers. They also may help companies develop plans to enter new lines of business or new geographic markets with existing lines of business by forecasting demand in competitive settings.

Most actuaries are employed in the insurance industry, in which they estimate the amount a company will pay in claims. For example, property/casualty actuaries calculate the expected amount of claims resulting from automobile accidents, which varies depending on the insured person's age, sex, driving history, type of car, and other factors. Actuaries ensure that the price, or premium, charged for such insurance will enable the company to cover claims and other expenses. This premium must be profitable and yet competitive with other insurance companies.

Actuaries employed in other industries perform several different functions. The small but growing group of actuaries in the financial services industry, for example, manages credit and helps price corporate security offerings. Because banks now offer their customers investment products such as annuities and asset management services, actuaries increasingly help financial institutions manage the substantial risks associated with these products. Actuaries employed as pension actuaries enrolled under the provisions of the Employee Retirement Income Security Act (ERISA) of 1974 evaluate pension plans covered by that act and report on their financial soundness to plan members, sponsors, and Federal regulators. Actuaries working in government help manage social programs such as Social Security and Medicare.

In addition to salaried actuaries, numerous consulting actuaries provide advice to clients on a contract basis. Their clients include insurance companies, corporations, health maintenance organizations, healthcare providers, government agencies, and attorneys. The duties of most consulting actuaries are similar to those of other actuaries. For example, some design pension plans through calculating the future value of current deductions from earnings and by determining the amount of employer contributions. Others provide advice to healthcare plans or financial services firms. Consultants sometimes testify in court regarding the value of potential lifetime earnings of a person who is disabled or killed in an accident, the current value of future pension benefits in divorce cases, or other complex calculations. Many consulting actuaries work in reinsurance, in which one insurance company arranges to share a large prospective liability policy with another insurance company in exchange for a percentage of the premium.



*Actuaries perform complex mathematical analysis that assists organizations in making important operational decisions.*

**Working Conditions**

Actuaries have desk jobs, and their offices usually are comfortable and pleasant. They often work at least 40 hours a week. Some actuaries, particularly consulting actuaries, may travel to meet with clients. Consulting actuaries also may experience more erratic employment and be expected to work more than 40 hours per week.

**Employment**

Actuaries held about 14,000 jobs in 2000. Over seven-tenths of the actuaries who were wage and salary workers were employed in the insurance industry. Some had jobs in life and health insurance

companies, while property and casualty insurance companies, pension funds, or insurance agents and brokers employed others. Most of the remaining actuaries worked for firms providing a variety of corporate services, especially management and public relations, or for actuarial consulting services. A relatively small number of actuaries was employed by security and commodity brokers or by government agencies. Some developed computer software for actuarial calculations.

**Training, Other Qualifications, and Advancement**

As with many business positions, actuaries need a strong background in mathematics and general business. Applicants for beginning actuarial jobs usually have a bachelor's degree in mathematics, actuarial science, statistics, or a business-related discipline, such as economics, finance, or accounting. About 100 colleges and universities offer an actuarial science program, and most colleges and universities offer a degree in mathematics or statistics. Some companies hire applicants without specifying a major, provided that the applicant has a working knowledge of mathematics, including calculus, probability, and statistics, and has demonstrated this ability by passing one or two actuarial exams required for professional designation. Courses in economics, accounting, finance, and insurance also are useful. Companies increasingly prefer well-rounded individuals who, in addition to a strong technical background, have some training in liberal arts and business, and possess strong communication skills.

In addition to knowledge of mathematics, computer skills are becoming increasingly important. Actuaries should be able to develop and use spreadsheets and databases, as well as standard statistical analysis software. Knowledge of computer programming languages, such as Visual Basic, also is useful.

Two professional societies sponsor programs leading to full professional status in their specialty. The first, the Society of Actuaries (SOA), administers a series of actuarial examinations for the life and health insurance, pension, and finance and investment fields. The Casualty Actuarial Society (CAS), on the other hand, gives a series of examinations for the property and casualty field, which includes fire, accident, medical malpractice; workers compensation; and personal injury liability.

The first four exams of the SOA and CAS examination series are jointly sponsored by the two societies and cover the same material. For this reason, students do not need to commit themselves to a specialty until they have taken the initial examinations. These test an individual's competence in probability, calculus, statistics, and other branches of mathematics. The first few examinations help students evaluate their potential as actuaries. Many prospective actuaries begin taking the exams in college with the help of self-study guides and courses. Those who pass one or more examinations have better opportunities for employment at higher starting salaries than those who do not.

Actuaries are encouraged to complete the entire series of examinations as soon as possible, advancing first to the associate level, and then to the fellowship level. Advanced casualty topics include investment and assets, dynamic financial analysis, and valuation of insurance topics. Candidates in the SOA examination series must choose a specialty—group and health benefits, individual life and annuities, pensions, investments, or finance. Examinations are given twice a year, in the spring and the fall. Although many companies allot time to their employees for study, extensive home study is required to pass the examinations, and many actuaries study for months to prepare for each examination. It is likewise common for employers to pay the hundreds of dollars for fees and study materials. Most reach the associate level within 4 to 6 years and the fellowship level a few years later.

Specific requirements apply for pension actuaries, who verify the financial status of defined benefit pension plans to the Federal Government. These actuaries must be enrolled by the Joint Board for the Enrollment of Actuaries. To qualify for enrollment, applicants must meet certain experience and examination requirements, as stipulated by the Joint Board.

To perform their duties effectively, actuaries must keep up with current economic and social trends and legislation, as well as with developments in health, business, finance, and economics that could affect insurance or investment practices. Good communication and interpersonal skills also are important, particularly for prospective consulting actuaries.

Beginning actuaries often rotate among different jobs in an organization to learn various actuarial operations and phases of insurance work, such as marketing, underwriting, and product development. At first, they prepare data for actuarial projects or perform other simple tasks. As they gain experience, actuaries may supervise clerks, prepare correspondence, draft reports, and conduct research. They may move from one company to another early in their careers as they move up to higher positions.

Advancement depends largely on job performance and the number of actuarial examinations passed. Actuaries with a broad knowledge of the insurance, pension, investment, or employee benefits fields can advance to administrative and executive positions in their companies. Actuaries with supervisory ability may advance to management positions in other areas, such as underwriting, accounting, data processing, marketing, or advertising. Some actuaries assume college and university faculty positions. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

**Job Outlook**

This small occupation generates relatively few job openings from employment growth and the need to replace those who leave the occupation each year. The fastest employment growth is expected in the computer and data processing services, health services, and management and actuarial consulting industries. Employment of actuaries is expected to grow more slowly than the average for all occupations through 2010, as projected job growth in these industries is offset by a slowdown in actuarial employment growth in insurance industries, which traditionally employ the majority of actuaries.

New employment opportunities should become available in health services, in medical and health insurance industries, and in government—in healthcare and Social Security. Changes in managed healthcare and the desire to contain healthcare costs will continue to provide opportunities for actuaries. Some actuaries also are evaluating the risks associated with controversial medical issues, such as genetic testing or the impact of diseases such as AIDS. Others in this field are involved in drafting healthcare legislation. As healthcare issues and Social Security reform continue to receive growing attention, opportunities for actuaries should increase.

Actuaries will continue to be needed to evaluate risks associated with catastrophes, such as earthquakes, tornadoes, hurricanes, floods, and other natural disasters. Growing areas in property and casualty insurance are environmental and international risk management. Actuaries evaluate risks such as the likelihood of a toxic waste spill, or the costs and benefits of implementing pollution control equipment in a factory. As economic globalization continues and companies expand their operations abroad, they increasingly rely on actuaries to evaluate the risk of setting up a new factory or acquiring a foreign subsidiary.

The banking and securities and commodities industries also should provide additional jobs for actuaries. As financial services continue to consolidate and insurance firms, banks, and securities

firms enter one another's markets, new opportunities will emerge. Actuaries will be needed to analyze the risks associated with entering a new market, such as launching a new service or merging with an already established company.

At the same time, changes in consumer preferences for retirement investment plans will adversely affect employment in the life insurance and pension funds industries. The overall decline in the life insurance industry, reflecting fewer life insurance policies sold in favor of investments earning higher returns, will continue to affect the need for actuaries. Similarly, more people are choosing to invest in defined contribution plans, which are less complicated to analyze and, therefore, require fewer actuaries than defined pension systems. Actuaries in the pension funds industry are more likely to be involved in financial planning—helping people manage their retirement money.

Layoffs in the insurance and financial industries due to downsizing and mergers also affect employment. Many of the actuaries released from insurance firms are choosing to establish consulting practices. Jobs should be available for actuaries working in consulting as firms who do not employ their own actuarial staff continue to hire consulting actuaries to analyze various risks.

**Earnings**

Median annual earnings of actuaries were $66,590 in 2000. The middle 50 percent earned between $47,260 and $93,140. The lowest 10 percent had earnings of less than $37,130, while the top 10 percent earned over $127,360. The average salary for actuaries employed by the Federal Government was $78,120 in 2001.

According to the National Association of Colleges and Employers, annual starting salaries for bachelor's degree graduates in actuarial science averaged $45,753 in 2001.

Insurance companies and consulting firms give merit increases to actuaries as they gain experience and pass examinations. Some companies also offer cash bonuses for each professional designation achieved. A 2001 salary survey of insurance and financial services companies, conducted by the Life Office Management Association, Inc., indicated that the average base salary for an entry-level actuary with the largest U.S. companies was $44,546. Associate actuaries with the largest U.S. companies, who direct and provide leadership in the design, pricing, and implementation of insurance products, received an average salary of $91,544. Actuaries at the highest technical level without managerial responsibilities in the same size companies earned an average of $108,777.

**Related Occupations**

Actuaries need a strong background in mathematics, statistics, and related fields. Other workers whose jobs involve related skills include accountants and auditors, budget analysts, economists and market and survey researchers, financial analysts and personal financial advisors, insurance underwriters, mathematicians, and statisticians.

**Sources of Additional Information**

Career information on actuaries specializing in pensions is available from:

➤ American Society of Pension Actuaries, 4245 N. Fairfax Dr., Suite 750, Arlington, VA 22203. Internet: **http://www.aspa.org**

For information about actuarial careers in life and health insurance, employee benefits and pensions, and finance and investments, contact:

➤ Society of Actuaries (SOA), 475 N. Martingale Rd., Suite 800, Schaumburg, IL 60173-2226. Internet: **http://www.soa.org**

For information about actuarial careers in property and casualty insurance, contact:

➤ Casualty Actuarial Society (CAS), 1100 N. Glebe Rd., Suite 600, Arlington, VA 22201. Internet: **http://www.casact.org**

The SOA and CAS jointly sponsor a Web site for those interested in pursuing an actuarial career. Internet: **http://www.BeAnActuary.org**

For general facts about actuarial careers, contact:

➤ American Academy of Actuaries, 1100 17th St. NW., 7th Floor, Washington, DC 20036. Internet: **http://www.actuary.org/index.htm**

## Computer Programmers

(O*NET 15-1021.00)

**Significant Points**

- Employment growth will be considerably slower than that of other computer specialists, due to the spread of pre-packaged software solutions.
- Three out of 5 computer programmers held at least a bachelor's degree in 2000.
- Prospects should be best for college graduates with knowledge of a variety of programming languages and tools; those with less formal education or its equivalent in work experience should face strong competition for programming jobs.

**Nature of the Work**

Computer programmers write, test, and maintain the detailed instructions, called programs, that computers must follow to perform their functions. They also conceive, design, and test logical structures for solving problems by computer. Many technical innovations in programming—advanced computing technologies and sophisticated new languages and programming tools—have redefined the role of a programmer and elevated much of the programming work done today. Job titles and descriptions may vary, depending on the organization. In this occupational statement, *computer programmer* refers to individuals whose main job function is programming; this group has a wide range of responsibilities and educational backgrounds.

Computer programs tell the computer what to do, such as which information to identify and access, how to process it, and what equipment to use. Programs vary widely depending upon the type of information to be accessed or generated. For example, the instructions involved in updating financial records are very different from those required to duplicate conditions on board an aircraft for pilots training in a flight simulator. Although simple programs can be written in a few hours, programs that use complex mathematical formulas, whose solutions can only be approximated, or that draw data from many existing systems, may require more than a year of work. In most cases, several programmers work together as a team under a senior programmer's supervision.

Programmers write programs according to the specifications determined primarily by computer software engineers and system analysts. (Separate statements on computer software engineers and systems analysts, computer scientists, and database administrators appear elsewhere in the *Handbook*.) After the design process is complete, it is the job of the programmer to convert that design into a logical series of instructions that the computer can follow. They then code these instructions in a conventional programming language, such as COBOL; an artificial intelligence language, such as Prolog; or one of the most advanced object-oriented languages such

as Java, C++, or Smalltalk. Different programming languages are used depending on the purpose of the program. COBOL, for example, is commonly used for business applications, whereas Fortran (short for "formula translation") is used in science and engineering. C++ is widely used for both scientific and business applications. Programmers generally know more than one programming language; and since many languages are similar, they often can learn new languages relatively easily. In practice, programmers often are referred to by the language they know, such as Java programmers, or the type of function they perform or environment in which they work, such as database programmers, mainframe programmers, or Internet programmers.

Many programmers update, repair, modify, and expand existing programs. When making changes to a section of code, called a *routine*, programmers need to make other users aware of the task the routine is to perform. They do this by inserting comments in the coded instructions, so others can understand the program. Many programmers use computer-assisted software engineering (CASE) tools to automate much of the coding process. These tools enable a programmer to concentrate on writing the unique parts of the program, because the tools automate various pieces of the program being built. CASE tools generate whole sections of code automatically, rather than line by line. This also yields more reliable and consistent programs and increases programmers' productivity by eliminating some routine steps.

Programmers test a program by running it, to ensure the instructions are correct and it produces the desired information. If errors do occur, the programmer must make the appropriate change and recheck the program until it produces the correct results. This process is called debugging. Programmers may continue to fix these problems throughout the life of a program. Programmers working in a mainframe environment may prepare instructions for a computer operator who will run the program. (A separate statement on computer operators appears elsewhere in the *Handbook*.) They also may contribute to a manual for users.

Programmers often are grouped into two broad types—applications programmers and systems programmers. *Applications programmers* write programs to handle a specific job, such as a program to track inventory, within an organization. They may also revise existing packaged software. *Systems programmers*, on the other hand, write programs to maintain and control computer systems software, such as operating systems, networked systems, and database systems. These workers make changes in the sets of instructions that determine how the network, workstations, and central processing unit of the system handle the various jobs they have been given and how they communicate with peripheral equipment, such as terminals, printers, and disk drives. Because of their knowledge of the entire computer system, systems programmers often help applications programmers determine the source of problems that may occur with their programs.

Programmers in software development companies may work directly with experts from various fields to create software—either programs designed for specific clients or packaged software for general use—ranging from games and educational software to programs for desktop publishing, financial planning, and spreadsheets. Much of this type of programming is in the preparation of packaged software, which comprises one of the most rapidly growing segments of the computer services industry.

In some organizations, particularly small ones, workers commonly known as *programmer-analysts* are responsible for both the systems analysis and the actual programming work. (A more detailed description of the work of programmer-analysts is presented in the statement on systems analysts, computer scientists, and database administrators elsewhere in the *Handbook.*) Advanced

*Computer programmers write programs according to the specifications determined by software engineers or systems analysts.*

programming languages and new object-oriented programming capabilities are increasing the efficiency and productivity of both programmers and users. The transition from a mainframe environment to one that is primarily personal computer (PC) based has blurred the once rigid distinction between the programmer and the user. Increasingly, adept end-users are taking over many of the tasks previously performed by programmers. For example, the growing use of packaged software, like spreadsheet and database management software packages, allows users to write simple programs to access data and perform calculations.

**Working Conditions**

Programmers generally work in offices in comfortable surroundings. Many programmers may work long hours or weekends, to meet deadlines or fix critical problems that occur during off hours. Given the technology available, telecommuting is becoming common for a wide range of computer professionals—including computer programmers. As computer networks expand, more programmers are able to connect to a customer's computer system remotely to make corrections or fix problems, using modems, e-mail, and the Internet.

Like other workers who spend long periods of time in front of a computer terminal typing at a keyboard, programmers are susceptible to eyestrain, back discomfort, and hand and wrist problems, such as carpal tunnel syndrome.

**Employment**

Computer programmers held about 585,000 jobs in 2000. Programmers are employed in almost every industry, but the largest concentration is in the computer and data processing services industry, which includes firms that write and sell software. Large numbers of programmers can also be found working for firms that provide engineering and management services, telecommunications companies, manufacturers of computer and office equipment, financial institutions, insurance carriers, educational institutions, and government agencies.

A large number of computer programmers are employed on a temporary or contract basis or work as independent consultants, as companies demand expertise with new programming languages or specialized areas of application. Rather than hiring programmers as permanent employees and then laying them off after a job is completed, employers can contract with temporary help agencies, consulting firms, or directly with programmers themselves. A marketing firm, for example, may only require the services of several programmers to write and debug the software necessary to get a new customer resource management system running. This practice also enables companies to bring in people with a specific set of skills—usually in one of the latest technologies—as it applies to their business needs. Bringing in an independent contractor or consultant with a certain level of experience in a new or advanced programming language, for example, enables an establishment to complete a particular job without having to retrain existing workers. Such jobs may last anywhere from several weeks to a year or longer. There were 22,000 self-employed computer programmers in 2000.

**Training, Other Qualifications, and Advancement**

While there are many training paths available for programmers, mainly because employers' needs are so varied, the level of education and experience employers seek has been rising, due to the growing number of qualified applicants and the specialization involved with most programming tasks. Bachelor's degrees are commonly required, although some programmers may qualify for certain jobs with 2-year degrees or certificates. Employers are primarily interested in programming knowledge, and computer programmers are able to get certified in a language such as C++ or Java. College graduates who are interested in changing careers or developing an area of expertise also may return to a 2-year community college or technical school for additional training. In the absence of a degree, substantial specialized experience or expertise may be needed. Even with a degree, employers appear to be placing more emphasis on previous experience, for all types of programmers.

**Table 1. Highest level of school completed or degree received, computer programmers, 2000**

| | *Percent* |
|---|---|
| High school graduate or equivalent or less | 11.8 |
| Some college, no degree | 17.2 |
| Associate degree | 11.0 |
| Bachelor's degree | 47.4 |
| Graduate degree | 12.8 |

About 3 out of 5 computer programmers had a bachelor's degree or higher in 2000 (table 1). Of these, some hold a degree in computer science, mathematics, or information systems, whereas others have taken special courses in computer programming to supplement their study in fields such as accounting, inventory control, or other areas of business. As the level of education and training required by employers continues to rise, this proportion should increase in the future.

Required skills vary from job to job, but the demand for various skills generally is driven by changes in technology. Employers using computers for scientific or engineering applications usually prefer college graduates who have degrees in computer or information science, mathematics, engineering, or the physical sciences. Graduate degrees in related fields are required for some jobs. Employers who use computers for business applications prefer to hire people who have had college courses in management information systems (MIS) and business and who possess strong programming skills. Although knowledge of traditional languages still is important, increasing emphasis is placed on newer, object-oriented programming languages and tools, such as C++ and Java. Additionally, employers are seeking persons familiar with fourth and fifth generation languages that involve graphic user interface (GUI) and systems programming. Employers also prefer applicants who have general business skills and experience related to the operations of the firm. Students can improve their employment prospects by participating in a college work-study program or by undertaking an internship.

Most systems programmers hold a 4-year degree in computer science. Extensive knowledge of a variety of operating systems is essential. This includes being able to configure an operating system to work with different types of hardware and adapting the operating system to best meet the needs of a particular organization. Systems programmers also must be able to work with database systems, such as DB2, Oracle, or Sybase, for example.

When hiring programmers, employers look for people with the necessary programming skills who can think logically and pay close attention to detail. The job calls for patience, persistence, and the ability to work on exacting analytical work, especially under pressure. Ingenuity and imagination also are particularly important, when programmers design solutions and test their work for potential failures. The ability to work with abstract concepts and to do technical analysis is especially important for systems programmers, because they work with the software that controls the computer's operation. Because programmers are expected to work in teams and interact directly with users, employers want programmers who are able to communicate with nontechnical personnel.

Entry-level or junior programmers may work alone on simple assignments after some initial instruction or on a team with more experienced programmers. Either way, beginning programmers generally must work under close supervision. Because technology changes so rapidly, programmers must continuously update their training by taking courses sponsored by their employer or software vendors.

For skilled workers who keep up to date with the latest technology, the prospects for advancement are good. In large organizations, programmers may be promoted to lead programmer and be given supervisory responsibilities. Some applications programmers may move into systems programming after they gain experience and take courses in systems software. With general business experience, programmers may become programmer analysts or systems analysts or be promoted to a managerial position. Other programmers, with specialized knowledge and experience with a language or operating system, may work in research and development areas, such as multimedia or Internet technology. As employers increasingly contract out programming jobs, more opportunities should arise for experienced programmers with expertise in a specific area to work as consultants.

Technical or professional certification is a way to demonstrate a level of competency or quality. In addition to language-specific certificates that a programmer can obtain, product vendors or software firms also offer certification and may require professionals who work with their products to be certified. Voluntary certification also is available through other organizations. Professional certification may provide a job seeker a competitive advantage.

**Job Outlook**

Employment of programmers is expected to grow about as fast as the average for all occupations through 2010. Jobs for both systems and applications programmers should be most plentiful in data processing service firms, software houses, and computer consulting businesses. These types of establishments are part of computer and data processing services, which is projected to be the fastest growing industry in the economy over the 2000-10 period. As organizations attempt to control costs and keep up with changing

technology, they will need programmers to assist in conversions to new computer languages and systems. In addition, numerous job openings will result from the need to replace programmers who leave the labor force or transfer to other occupations such as manager or systems analyst.

Employment of programmers, however, is expected to grow much slower than that of other computer specialists. With the rapid gains in technology, sophisticated computer software now has the capability to write basic code, eliminating the need for more programmers to do this routine work. The consolidation and centralization of systems and applications, developments in packaged software, advanced programming languages and tools, and the growing ability of users to design, write, and implement more of their own programs means more of the programming functions can be transferred to other types of workers. As the level of technological innovation and sophistication increases, programmers should continue to face increasing competition from programming businesses overseas where much routine work can be contracted out at a lower cost.

Nevertheless, employers will continue to need programmers who have strong technical skills and who understand an employer's business and its programming needs. This will mean that programmers will need to keep up with changing programming languages and techniques. Given the importance of networking and the expansion of client/server environments and web-based environments, organizations will look for programmers who can support data communications and help implement electronic commerce and intranet strategies. Demand for programmers with strong object-oriented programming capabilities and technical specialization in areas such as client/server programming, multimedia technology, and graphic user interface (GUI), should arise from the expansion of intranets, extranets, and Internet applications. Programmers also will be needed to create and maintain expert systems and embed these technologies in more and more products.

As programming tasks become increasingly sophisticated and an additional level of skill and experience is demanded by employers, graduates of 2-year programs and people with less than a 2-year degree or its equivalent in work experience should face strong competition for programming jobs. Competition for entry-level positions, however, also can affect applicants with a bachelor's degree. Prospects should be best for college graduates with knowledge of, and experience working with, a variety of programming languages and tools—including C++ and other object-oriented languages like Java, as well as newer, domain-specific languages that apply to computer networking, data base management, and Internet application development. Obtaining vendor or language specific certification also can provide a competitive edge. Because demand fluctuates with employers' needs, job seekers should keep up to date with the latest skills and technologies. Individuals who want to become programmers can enhance their prospects by combining the appropriate formal training with practical work experience.

**Earnings**

Median annual earnings of computer programmers were $57,590 in 2000. The middle 50 percent earned between $44,850 and $74,500 a year. The lowest 10 percent earned less than $35,020; the highest 10 percent earned more than $93,210. Median annual earnings in the industries employing the largest numbers of computer programmers in 2000 were:

| | |
|---|---|
| Personnel supply services | $65,780 |
| Professional and commercial equipment | 63,780 |
| Computer and data processing services | 61,010 |
| Commercial banks | 60,180 |
| Management and public relations | 57,120 |

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer programming averaged $48,602 a year in 2001.

According to Robert Half International, average annual starting salaries in 2001 ranged from $58,500 to $90,000 for applications development programmers/developers, and from $54,000 to $77,750 for software development programmers/analysts. Average starting salaries for Internet programmers/analysts ranged from $56,500 to $84,000.

**Related Occupations**

Other professional workers who deal with data and detail include computer software engineers; systems analysts, computer scientists, and database administrators; statisticians; mathematicians; engineers; financial analysts and personal financial advisors; accountants and auditors; actuaries; and operations research analysts.

**Sources of Additional Information**

State employment service offices can provide information about job openings for computer programmers. Municipal chambers of commerce are other sources of information on an area's largest employers.

For information about certification as a computing professional, contact:

➤ Institute for Certification of Computing Professionals (ICCP), 2350 East Devon Ave., Suite 115, Des Plaines, IL 60018. Internet: **http://www.iccp.org**

Further information about computer careers is available from:

➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**

➤ IEEE Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

## Computer Software Engineers

(O*NET 15-1031.00, 15-1032.00)

**Significant Points**

- Computer software engineers are projected to be the fastest growing occupation over the 2000-10 period.
- Very favorable opportunities are expected for college graduates with at least a bachelor's degree in computer engineering or computer science and practical experience working with computers.
- Computer software engineers must continually strive to acquire new skills as computer technology changes rapidly.

**Nature of the Work**

The explosive impact of computers and information technology on our everyday lives has generated a need to design and develop new computer software systems and to incorporate new technologies in a rapidly growing range of applications. The tasks performed by workers known as computer software engineers evolve rapidly, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers. Computer software engineers apply the principles and techniques of computer science, engineering, and mathematical analysis to the design,

development, testing, and evaluation of the software and systems that enable computers to perform their many applications. (A separate statement on computer hardware engineers appears elsewhere in the *Handbook*.)

Software engineers working in applications or systems development analyze users' needs and design, create, and modify general computer applications software or systems. Software engineers can be involved in the design and development of many types of software including software for operating systems, network distribution, and compilers, which convert programs for faster processing. In programming, or coding, software engineers instruct a computer, line by line, how to perform a function. They also solve technical problems that arise. Software engineers must possess strong programming skills, but are more concerned with developing algorithms and analyzing and solving programming problems than with actually writing code. (A separate statement on computer programmers appears elsewhere in the Handbook).

*Computer applications software engineers* analyze users' needs and design, create, and modify general computer applications software or specialized utility programs. Different programming languages are used, depending on the purpose of the program. The programming languages most often used are C, C++, and Java, with Fortran and Cobol used less commonly. Some software engineers develop both packaged systems and systems software or create customized applications.

*Computer systems software engineers* coordinate the construction and maintenance of a company's computer systems, and plan their future growth. Working with a company, they coordinate each department's computer needs—ordering, inventory, billing, and payroll recordkeeping, for example—and make suggestions about its technical direction. They also might set up the company's intranets, networks that link computers within the organization and ease communication.

Systems software engineers work for companies that configure, implement, and install complete computer systems. They may be members of the marketing or sales staff, where they serve as the primary technical resource for salesworkers and customers. They also may be involved in product sales and in providing their customers with continuing technical support.

Computer software engineers often work as part of a team that designs new hardware, software, and systems. A core team may comprise engineering, marketing, manufacturing, and design people who work together until the product is released.

*Computer software engineers design, develop, and test many types of software.*

**Working Conditions**

Computer software engineers normally work in well-lighted and comfortable offices or computer laboratories in which computer equipment is located. Most software engineers work at least 40 hours a week; however, due to the project-oriented nature of the work, they also may have to work evenings or weekends to meet deadlines or solve unexpected technical problems. And like other workers who sit for hours at a computer typing on a keyboard, software engineers are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Many computer software engineers interact with customers and coworkers as they strive to improve software for users. Those employed by software vendors and consulting firms, for example, spend much of their time away from their offices, frequently traveling overnight, to meet with customers. They call on customers in businesses ranging from manufacturing plants to financial institutions.

As networks expand, software engineers may be able to use modems, laptops, e-mail, and the Internet to provide more technical support and other services from their main office, connecting to a customer's computer remotely to identify and correct developing problems.

**Employment**

Computer software engineers held about 697,000 jobs in 2000. About 380,000 were computer software engineers, applications, and about 317,000 were computer software engineers, systems software. Although they are employed in most industries, the largest concentration of computer software engineers, almost 46 percent, is in the computer and data processing services industry. This industry includes firms that develop and produce prepackaged software and firms that provide contractual computer services such as computer programming, systems integration, and information retrieval, including online databases and Internet services. Many computer software engineers also work for establishments in other industries, such as government agencies, manufacturers of computers and related electronic equipment, and colleges and universities.

Employers of computer software engineers range from startup companies to established industry leaders. The proliferation of Internet, e-mail, and other communications systems expands electronics to engineering firms traditionally associated with unrelated disciplines. Engineering firms specializing in building bridges and power plants, for example, hire computer software engineers to design and develop new geographic data systems and automated drafting capabilities. Communications firms need computer software engineers to tap into growth in the personal communications market. Major communications companies have many job openings for both computer software applications and systems engineers.

A increasing number of computer software engineers are employed on a temporary or contract basis—many of whom are self-employed, working independently as consultants. Some consultants work for firms that specialize in developing and maintaining client companies' websites and intranets. Consulting opportunities for software engineers should grow as businesses need help managing, upgrading, and customizing increasingly complex computer systems. About 49,000 computer software engineers were self-employed in 2000.

**Training, Other Qualifications, and Advancement**

Most employers prefer to hire persons who have at least a bachelor's degree and broad knowledge and experience with computer systems and technologies. Usual degree concentrations for applications software engineers are computer science or software engineering; for systems software engineers, usual concentrations are computer science or computer information systems. Graduate degrees are preferred for some of the more complex jobs.

Academic programs in software engineering emphasize software and may be offered as a degree option or in conjunction with computer science degrees. Students seeking software engineering jobs enhance their employment opportunities by participating in internship or co-op programs offered through their schools. These experiences provide students with broad knowledge and experience, making them more attractive candidates to employers. Inexperienced college graduates may be hired by large computer and consulting firms that train new hires in intensive, company-based programs. In many firms, mentoring has become part of the evaluation process for new employees.

For systems software engineering jobs that require workers who have a college degree, a bachelor's in computer science or computer information systems is typical. For systems engineering jobs that place less emphasis on workers having a computer-related degree, computer training programs are offered by systems software vendors, including Microsoft, Novell, and Oracle. These training programs usually last from 1 to 4 weeks but are not required in order to sit for a certification exam; several study guides also are available to help prepare for the exams. However, many training authorities feel that program certification alone is not sufficient for most software engineering jobs.

Professional certification is offered by the Institute for Certification of Computing Professionals. This voluntary certification is available to those who have a college degree and at least 2 years of experience. Candidates must pass an examination covering general knowledge and two specialty areas or one specialty area and two computer programming languages. In addition, the Institute of Electrical and Electronics Engineers Computer Society recently announced plans to certify software engineers who pass an examination.

Persons interested in jobs as computer software engineers must have strong problem-solving and analytical skills. They also must be able to communicate effectively with team members, other staff, and the customers they meet. And because they often deal with a number of tasks simultaneously, they must be able to concentrate and pay close attention to detail.

As is the case with most occupations, advancement opportunities for computer software engineers increase with experience. Entry-level computer software engineers are likely to test and verify ongoing designs. As they become more experienced, computer software engineers may be involved in designing and developing software. They eventually may advance to become a project manager, manager of information systems, or chief information officer. Some computer software engineers with several years of experience or expertise find lucrative opportunities working as systems designers or independent consultants or starting their own computer consulting firms.

As technological advances in the computer field continue, employers demand new skills. Computer software engineers must continually strive to acquire new skills if they wish to remain in this extremely dynamic field. To help them keep up with the changing technology, continuing education and professional development seminars are offered by employers and software vendors, colleges and universities, private training institutions, and professional computing societies.

**Job Outlook**

Computer software engineers are projected to be the fastest growing occupation from 2000 to 2010. Very rapid employment growth in the computer and data processing services industry, which employs the greatest numbers of computer software engineers, should result in very favorable opportunities for those college graduates with at least a bachelor's degree in computer engineering or computer science and practical experience working with computers. Employers will continue to seek computer professionals with strong programming, systems analysis, interpersonal, and business skills.

Employment of computer software engineers is expected to increase much faster than the average for all occupations as businesses and other organizations continue to adopt and integrate new technologies and seek to maximize the efficiency of their computer systems. Competition among businesses will continue to create an incentive for increasingly sophisticated technological innovations, and organizations will need more computer software engineers to implement these new technological changes. In addition to employment growth, many job openings will result annually from the need to replace workers who move into managerial positions, transfer to other occupations, or who leave the labor force.

Demand for computer software engineers will increase as computer networking continues to grow. For example, the expanding integration of Internet technologies and the explosive growth in electronic commerce—doing business on the Internet—have resulted in rising demand for computer software engineers who can develop Internet, intranet, and other web applications. Likewise, expanding electronic data processing systems in business, telecommunications, government, and other settings continue to become more sophisticated and complex. Growing numbers of systems software engineers will be needed to implement, safeguard, and update systems and resolve problems. Consulting opportunities for computer software engineers also should continue to grow as businesses increasingly need help to manage, upgrade, and customize their increasingly complex computer systems.

**Earnings**

Median annual earnings of computer software engineers, applications, who worked full time in 2000 were about $67,670. The middle 50 percent earned between $53,390 and $85,490. The lowest 10 percent earned less than $42,710, and the highest 10 percent earned more than $106,680. Median annual earnings in the industries employing the largest numbers of computer applications software engineers in 2000 were:

| | |
|---|---|
| Computer and office equipment | $74,300 |
| Computer and data processing services | 69,520 |
| Engineering and architectural services | 68,790 |
| Professional and commercial equipment | 64,920 |
| Management and public relations | 62,660 |

Median annual earnings of computer software engineers, systems software, who worked full time in 2000 were about $69,530. The middle 50 percent earned between $54,460 and $86,520. The lowest 10 percent earned less than $43,600, and the highest 10 percent earned more than $105,240. Median annual earnings in the industries employing the largest numbers of computer systems software engineers in 2000 were:

| | |
|---|---|
| Computer and office equipment | $74,600 |
| Computer and data processing services | 70,150 |
| Telephone communication | 68,930 |
| Engineering and architectural services | 68,030 |
| Commercial banks | 65,620 |

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer engineering averaged $53,924 in 2001, and those with a master's degree averaged $58,026. Starting salary offers for graduates with a bachelor's degree in computer science averaged $52,723.

According to Robert Half International, starting salaries for software engineers in software development ranged from $62,750 to $92,000 in 2001.

In addition to typical benefits, computer software engineers may be provided with profit sharing, stock options, and a company car with a mileage allowance.

**Related Occupations**
Other workers who extensively use mathematics and logic include systems analysts, computer scientists, and database administrators; computer programmers; financial analysts and personal financial advisors; computer hardware engineers; statisticians; mathematicians; management analysts; actuaries; and operations research analysts.

**Sources of Additional Information**
Additional information on a career in computer software engineering is available from:

➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**

➤ IEEE Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

Further information about the Certified Computing Professional designation is available from:

➤ Institute for Certification of Computing Professionals (ICCP), 2350 East Devon Ave., Suite 115, Des Plaines, IL 60018. Internet: **http://www.iccp.org**

## Computer Support Specialists and Systems Administrators

(O*NET 15-1041.00, 15-1071.00)

**Significant Points**

- Computer support specialists and systems administrators are projected to be among the fastest growing occupations over the 2000-10 period.
- Job prospects should best for college graduates who are up to date with the latest skills and technologies; certifications and practical experience are essential for persons without degrees.

**Nature of the Work**
In the last decade, computers have become an integral part of everyday life, used for a variety of reasons at home, in the workplace, and at schools. And almost every computer user encounters a problem occasionally, whether it is the disaster of a crashing hard drive or the annoyance of a forgotten password. The explosion of computer use has created a high demand for specialists to provide advice to users, as well as day-to-day administration, maintenance, and support of computer systems and networks.

*Computer support specialists* provide technical assistance, support, and advice to customers and other users. This group includes *technical support specialists* and *help-desk technicians.* These troubleshooters interpret problems and provide technical support for hardware, software, and systems. They answer phone calls, analyze problems using automated diagnostic programs, and resolve recurrent difficulties. Support specialists may work either within a company that uses computer systems or directly for a computer hardware or software vendor. Increasingly, these specialists work for help-desk or support services firms, where they provide computer support on a contract basis to clients.

Technical support specialists are troubleshooters, providing valuable assistance to their organization's computer users. Because many nontechnical employees are not computer experts, they often run into computer problems they cannot resolve on their own. Technical support specialists install, modify, clean, and repair computer hardware and software. They also may work on monitors, keyboards, printers, and mice.

Technical support specialists answer phone calls from their organizations' computer users and may run automatic diagnostics programs to resolve problems. They also may write training manuals and train computer users how to properly use the new computer hardware and software. In addition, technical support specialists oversee the daily performance of their company's computer systems and evaluate software programs for usefulness.

Help-desk technicians assist computer users with the inevitable hardware and software questions not addressed in a product's instruction manual. Help-desk technicians field telephone calls and e-mail messages from customers seeking guidance on technical problems. In responding to these requests for guidance, help-desk technicians must listen carefully to the customer, ask questions to diagnose the nature of the problem, and then patiently walk the customer through the problem-solving steps.

Help-desk technicians deal directly with customer issues, and companies value them as a source of feedback on their products. These technicians are consulted for information about what gives customers the most trouble as well as their concerns. Most computer support specialists start out at the help desk.

*Network* or *computer systems administrators* design, install, and support an organization's LAN, WAN, network segment, Internet, or Intranet system. They provide day-to-day onsite administrative support for software users in a variety of work environments, including professional offices, small businesses, government, and large corporations. They maintain network hardware and software, analyze problems, and monitor the network to ensure availability to system users. These workers gather data to identify customer needs and then use that information to identify, interpret, and evaluate system and network requirements. Administrators also may plan, coordinate, and implement network security measures.

Systems administrators are the information technology employees responsible for the efficient use of networks by organizations. They ensure that the design of an organization's computer site allows all the components, including computers, the network, and software, to fit together and work properly. Furthermore, they monitor and adjust performance of existing networks and continually survey the current computer site to determine future network needs. Administrators also troubleshoot problems as reported by users and automated network monitoring systems and make recommendations for enhancements in the construction of future servers and networks.

*Computer support specialists answer telephone calls and respond to e-mail messages when assisting computer users.*

In some organizations, *computer security specialists* may plan, coordinate, and implement the organization's information security. These and other growing specialty occupations reflect the increasing emphasis on client-server applications, the expansion of Internet and Intranet applications, and the demand for more end-user support.

**Working Conditions**

Computer support specialists and systems administrators normally work in well lit, comfortable offices or computer laboratories. They usually work about 40 hours a week, but that may include evening or weekend work if the employer requires computer support over extended hours. Overtime may be necessary when unexpected technical problems arise. Like other workers who type on a keyboard for long periods, computer support specialists and systems administrators are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Due to the heavy emphasis on helping all types of computer users, computer support specialists and systems administrators constantly interact with customers and fellow employees as they answer questions and give valuable advice. Those who work as consultants are away from their offices much of the time, sometimes spending months working in a client's office.

As computer networks expand, more computer support specialists and systems administrators may be able to connect to a customer's computer remotely using modems, laptops, e-mail, and the Internet to provide technical support to computer users. This capability would reduce or eliminate travel to the customer's workplace. Systems administrators also can administer and configure networks and servers remotely, though it not as common as with computer support specialists.

**Employment**

Computer support specialists and systems administrators held about 734,000 jobs in 2000. Of these, about 506,000 were computer support specialists and about 229,000 were network and computer systems administrators. Although they worked in a wide range of industries, about one-third of all computer support specialists and systems administrators were employed in business services industries, principally computer and data processing services. Other industries that employed substantial numbers of these workers include banks, government agencies, insurance companies, educational institutions, and wholesale and retail vendors of computers, office equipment, appliances, and home electronic equipment. Many computer support specialists also worked for manufacturers of computers and other office equipment and for firms making electronic components and other accessories.

Employers of computer support specialists and systems administrators range from start-up companies to established industry leaders. With the continued development of the Internet, telecommunications, and e-mail, industries not typically associated with computers—such as construction—increasingly need computer-related workers. Small and large firms across all industries are expanding or developing computer systems, creating an immediate need for computer support specialists and systems administrators.

**Training, Other Qualifications, and Advancement**

Due to the wide range of skills required, there are a multitude of ways workers can become a computer support specialist or a systems administrator. While there is no universally accepted way to prepare for a job as a computer support specialist, many employers prefer to hire persons with some formal college education. A bachelor's degree in computer science or information systems is a prerequisite for some jobs; however, other jobs may require only a computer-related associate degree. For systems administrators, many employers seek applicants with bachelor's degrees, though not necessarily in a computer-related field.

Many companies are becoming more flexible about requiring a college degree for support positions because of the explosive demand for specialists. However, certification and practical experience demonstrating these skills will be essential for applicants without a degree. Completion of a certification training program, offered by a variety of vendors and product makers, may help some people to qualify for entry-level positions. Relevant computer experience may substitute for formal education.

Beginning computer support specialist start out at an organization dealing directly with customers or in-house users. Then, they may advance into more responsible positions in which they use what they learn from customers to improve the design and efficiency of future products. Job promotions usually depend more on performance than on formal education. Eventually, some computer support specialists become applications developers, designing products rather than assisting users. Computer support specialists at hardware and software companies often enjoy great upward mobility; advancement sometimes comes within months of initial employment.

Entry-level network and computer systems administrators are involved in routine maintenance and monitoring of computer systems, typically working behind the scenes in an organization. After gaining experience and expertise, they often are able to advance into more senior-level positions in which they take on more responsibilities. For example, senior network and computer systems administrators may present recommendations to management on matters related to a company's network. They also may translate the needs of an organization into a set of technical requirements, based on the available technology. As with support specialists, administrators may become software engineers, actually involved in the designing of the system or network, not just the day-to-day administration.

Persons interested in becoming a computer support specialist or systems administrator must have strong problem-solving, analytical, and communication skills because troubleshooting and helping others are a vital part of the job. The constant interaction with other computer personnel, customers, and employees require computer support specialists and systems administrators to communicate effectively on paper, via e-mail, or in person. Strong writing skills are useful when preparing manuals for employees and customers.

As technology continues to improve, computer support specialists and systems administrators must keep their skills current and acquire new ones. Many continuing education programs are offered by employers, hardware and software vendors, colleges and universities, and private training institutions. Professional development seminars offered by computing services firms also can enhance one's skills.

**Job Outlook**

Computer support specialists and systems administrators are projected to be among the fastest growing occupations over the 2000-10 period. Employment is expected to increase much faster than the average for all occupations as organizations continue to adopt and integrate increasingly sophisticated technology. Job growth will continue to be driven by rapid gains in computer and data processing services, which is projected to be the fastest growing industry in the U.S. economy.

The falling prices of computer hardware and software should help businesses expand their computing applications and integrate new technology into their operations. To maintain a competitive edge and operate more efficiently, firms will continue to demand computer specialists who are knowledgeable about the latest technologies and able to apply them to meet the needs of the organization.

Demand for computer support specialists is expected to increase because of the rapid pace of improved technology. As computers and software become more complex, support specialists will be needed to provide technical assistance to customers and other users. Consulting opportunities for computer support specialists also should continue to grow as businesses increasingly need help managing, upgrading, and customizing more complex computer systems.

Demand for systems administrators will grow as a result of the upsurge in electronic commerce and as computer applications continue to expand. Companies are looking for workers knowledgeable in the function and administration of networks. Such employees have become increasingly hard to find as systems administration has moved from being a separate function within corporations to one which forms a crucial element of business in an increasingly high-technology economy.

The growth of electronic commerce means more establishments use the Internet to conduct their business online. This translates into a need for information technology specialists who can help organizations use technology to communicate with employees, clients, and consumers. Explosive growth in these areas also is expected to fuel demand for specialists knowledgeable about network, data, and communications security.

Job prospects should be best for college graduates who are up to date with the latest skills and technologies, particularly if they have supplemented their formal education with some relevant work experience. Employers will continue to seek computer specialists who possess a strong background in fundamental computer skills combined with good interpersonal and communication skills. Due to the rapid growth in demand for computer support specialists and systems administrators, those who have strong computer skills but do not have a bachelor's degree should continue to qualify for some entry-level positions. However, certifications and practical experience are essential for persons without degrees.

**Earnings**

Median annual earnings of computer support specialists were $36,460 in 2000. The middle 50 percent earned between $27,680 and $48,440. The lowest 10 percent earned less than $21,260, and the highest 10 percent earned more than $63,480. Median annual earnings in the industries employing the largest numbers of computer support specialists in 2000 were:

| | |
|---|---|
| Professional and commercial equipment | $42,970 |
| Computer and data processing services | 37,860 |
| Personnel supply services | 34,080 |
| Colleges and universities | 32,830 |
| Miscellaneous business services | 21,070 |

Median annual earnings of network and computer systems administrators were $51,280 in 2000. The middle 50 percent earned between $40,450 and $65,140. The lowest 10 percent earned less than $32,450, and the highest 10 percent earned more than $81,150. Median annual earnings in the industries employing the largest number of network and computer systems administrators in 2000 were:

| | |
|---|---|
| Computer and data processing services | $54,400 |
| Telephone communication | 52,620 |
| Management and public relations | 51,340 |
| Elementary and secondary schools | 45,450 |
| Colleges and universities | 44,010 |

According to Robert Half International, starting salaries in 2001 ranged from $30,500 to $56,000 for help-desk support staff, and from $48,000 to $61,000 for more senior technical support specialists. For systems administrators, starting salaries in 2001 ranged from $50,250 to $70,750.

**Related Occupations**

Other computer-related occupations include computer programmers; computer software engineers; systems analysts, computer scientists, and database administrators; and operations research analysts.

**Sources of Additional Information**

For additional information about a career as a computer support specialist, contact:

➤ Association of Computer Support Specialists, 218 Huntington Rd., Bridgeport, CT 06608. Internet: **http://www.acss.org**

➤ Association of Support Professionals, 66 Mt. Auburn St., Watertown, MA 02472. Internet: **http://www.asponline.com**

For additional information about a career as a systems administrator, contact:

➤ System Administrators Guild, 2560 9th St., Suite 215, Berkeley, CA 94710. Internet: **http://www.sage.org**

Further information about computer careers is available from:

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

## Mathematicians

(O*NET 15-2021.00)

**Significant Points**

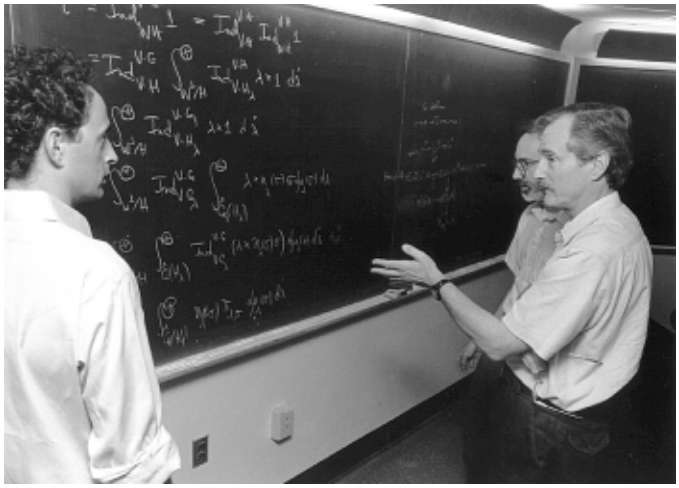
- A doctoral degree in mathematics usually is the minimum education needed, except in the Federal Government.
- Employment is expected to decline because very few jobs with the title mathematician are available.
- Master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as computer science or engineering, should have good employment opportunities in related occupations.

**Nature of the Work**

Mathematics is one of the oldest and most fundamental sciences. Mathematicians use mathematical theory, computational techniques, algorithms, and the latest computer technology to solve economic, scientific, engineering, physics, and business problems. The work of mathematicians falls into two broad classes—theoretical (pure) mathematics and applied mathematics. These classes, however, are not sharply defined, and often overlap.

*Theoretical mathematicians* advance mathematical knowledge by developing new principles and recognizing previously unknown relationships between existing principles of mathematics. Although they seek to increase basic knowledge without necessarily considering its practical use, such pure and abstract knowledge has been instrumental in producing or furthering many scientific and engineering achievements. Many theoretical mathematicians are employed as university faculty and divide their time between teaching and conducting research. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

*Applied mathematicians*, on the other hand, use theories and techniques, such as mathematical modeling and computational methods, to formulate and solve practical problems in business, government, engineering, and in the physical, life, and social sciences. For example, they may analyze the most efficient way to schedule airline routes between cities, the effect and safety of new drugs, the aerodynamic characteristics of an experimental automobile, or the cost-effectiveness of alternate manufacturing processes.



*Mathematicians use abstract mathematical concepts and theories in real-world applications.*

Applied mathematicians working in industrial research and development may develop or enhance mathematical methods when solving a difficult problem. Some mathematicians, called cryptanalysts, analyze and decipher encryption systems designed to transmit military, political, financial, or law enforcement-related information in code.

Applied mathematicians start with a practical problem, envision the separate elements of the process under consideration, and then reduce the elements into mathematical variables. They often use computers to analyze relationships among the variables and solve complex problems by developing models with alternate solutions.

Much of the work in applied mathematics is done by individuals with titles other than mathematician. In fact, because mathematics is the foundation upon which so many other academic disciplines are built, the number of workers using mathematical techniques is much greater than the number formally designated as mathematicians. For example, engineers, computer scientists, physicists, and economists are among those who use mathematics extensively. Some professionals, including statisticians, actuaries, and operations research analysts, actually are specialists in a particular branch of mathematics. Frequently, applied mathematicians are required to collaborate with other workers in their organizations to achieve common solutions to problems. (For more information, see the statements on actuaries, operations research analysts, and statisticians elsewhere in the *Handbook*.)

**Working Conditions**

Mathematicians usually work in comfortable offices. They often are part of an interdisciplinary team that may include economists, engineers, computer scientists, physicists, technicians, and others. Deadlines, overtime work, special requests for information or analysis, and prolonged travel to attend seminars or conferences may be part of their jobs. Mathematicians who work in academia usually have a mix of teaching and research responsibilities. These mathematicians often conduct research alone, or are aided by graduate students interested in the topic being researched.

**Employment**

Mathematicians held about 3,600 jobs in 2000. In addition, about 20,000 persons held full-time mathematics faculty positions in colleges and universities in 2000, according to the American Mathematical Society. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

Many nonfaculty mathematicians work for Federal or State governments. The U.S. Department of Defense is the primary Federal employer, accounting for about three-fourths of the mathematicians employed by the Federal Government. In the private sector, major employers include research and testing services, educational services, security and commodity exchanges, and management and public relations services. Within manufacturing, the aerospace and drug industries are the key employers. Some mathematicians also work for banks and insurance companies.

**Training, Other Qualifications, and Advancement**

A doctoral degree in mathematics usually is the minimum education needed for prospective mathematicians, except in the Federal Government. In the Federal Government, entry-level job candidates usually must have a 4-year degree with a major in mathematics or a 4-year degree with the equivalent of a mathematics major—24 semester hours of mathematics courses.

In private industry, candidates for mathematician jobs typically need a Masters or Ph.D. degree. Most of the positions designated for mathematicians are in research and development laboratories as part of technical teams. Research scientists in such positions engage either in basic research on pure mathematical principles or in applied research on developing or improving specific products or processes. The majority of those with a bachelor's or master's degree in mathematics who work in private industry do so not as mathematicians, but in related fields such as computer science, where they have titles such as computer programmer, systems analyst, or systems engineer.

A bachelor's degree in mathematics is offered by most colleges and universities. Mathematics courses usually required for this degree include calculus, differential equations, and linear and abstract algebra. Additional courses might include probability theory and statistics, mathematical analysis, numerical analysis, topology, discrete mathematics, and mathematical logic. Many colleges and universities urge or require students majoring in mathematics to take courses in a field that is closely related to mathematics, such as computer science, engineering, life science, physical science, or economics. A double major in mathematics and another discipline such as computer science, economics, or another one of the sciences is particularly desirable to many employers. A prospective college mathematics major should take as many mathematics courses as possible while in high school.

In 2001, about 200 colleges and universities offered a master's degree as the highest degree in either pure or applied mathematics; about 200 offered a Ph.D. degree in pure or applied mathematics. In graduate school, students conduct research and take advanced courses, usually specializing in a subfield of mathematics.

For jobs in applied mathematics, training in the field in which the mathematics will be used is very important. Mathematics is used extensively in physics, actuarial science, statistics, engineering, and operations research. Computer science, business and industrial management, economics, finance, chemistry, geology, life sciences, and behavioral sciences are likewise dependent on applied mathematics. Mathematicians also should have substantial knowledge of computer programming because most complex mathematical computation and much mathematical modeling is done on a computer.

Mathematicians need good reasoning ability and persistence in order to identify, analyze, and apply basic principles to technical problems. Communication skills are important, as mathematicians must be able to interact and discuss proposed solutions with people who may not have an extensive knowledge of mathematics.

**Job Outlook**

Employment of mathematicians is expected to decline through 2010, because very few jobs with the title mathematician are available. However, master's and Ph.D. degree holders with a strong background

in mathematics and a related discipline, such as engineering or computer science, should have good job opportunities. However, many of these workers have job titles that reflect their occupation, rather than the title mathematician.

Advancements in technology usually lead to expanding applications of mathematics, and more workers with knowledge of mathematics will be required in the future. However, jobs in industry and government often require advanced knowledge of related scientific disciplines in addition to mathematics. The most common fields in which mathematicians study and find work are computer science and software development, physics, engineering, and operations research. More mathematicians also are becoming involved in financial analysis. Mathematicians must compete for jobs, however, with people who have degrees in these other disciplines. The most successful jobseekers will be able to apply mathematical theory to real-world problems, and possess good communication, teamwork, and computer skills.

Private industry jobs require at least a master's degree in mathematics or in one of the related fields. Bachelor's degree holders in mathematics usually are not qualified for most jobs, and many seek advanced degrees in mathematics or a related discipline. However, bachelor's degree holders who meet State certification requirements may become primary or secondary school mathematics teachers. (For additional information, see the statement on teachers—preschool, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook*.)

Holders of a master's degree in mathematics will face very strong competition for jobs in theoretical research. Because the number of Ph.D. degrees awarded in mathematics continues to exceed the number of university positions available, many of these graduates will need to find employment in industry and government.

**Earnings**

Median annual earnings of mathematicians were $68,640 in 2000. The middle 50 percent earned between $50,740 and $85,520. The lowest 10 percent had earnings of less than $35,390, while the highest 10 percent earned over $101,900.

According to a 2001 survey by the National Association of Colleges and Employers, starting salary offers averaged $46,466 a year for mathematics graduates with a bachelor's degree, and $55,938 for those with a master's degree. Doctoral degree candidates averaged $53,440.

In early 2001, the average annual salary for mathematicians employed by the Federal Government in supervisory, nonsupervisory, and managerial positions was $76,460; for mathematical statisticians, it was $76,530, and for cryptanalysts, $70,840.

**Related Occupations**

Other occupations that require extensive knowledge of mathematics or, in some cases, a degree in mathematics include actuaries; statisticians; computer programmers; systems analysts, computer scientists, and database administrators; computer software engineers; and operations research analysts. A strong background in mathematics also facilitates employment as teachers—postsecondary, engineers, economists and survey and market researchers, financial analysts and personal financial advisors, and physicists and astronomers.

**Sources of Additional Information**

For more information about careers and training in mathematics, especially for doctoral-level employment, contact:

➤ American Mathematical Society, 201 Charles St., Providence, RI 02940. Internet: **http://www.ams.org**

For specific information on careers in applied mathematics, contact:

➤ Society for Industrial and Applied Mathematics, 3600 University City Science Center, Philadelphia, PA 19104-2688. Internet: **http://www.siam.org/alterindex.htm**

Information on obtaining a mathematician position with the Federal Government is available from the Office of Personnel Management (OPM) through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; Federal Relay Service: (800) 877-8339. The first number is not tollfree, and charges may result. Information also is available from the OPM Internet site: **http://www.usajobs.opm.gov**.

## Operations Research Analysts

(O*NET 15-2031.00)

**Significant Points**

- Individuals with a master's or Ph.D. degree in management science, operations research, or a closely related field should have good job prospects.
- Employment growth is projected to be slower than average because few job openings are expected to have the title *operations research analyst*.

**Nature of the Work**

Operations research and management science are terms that are used interchangeably to describe the discipline of applying advanced analytical techniques to help make better decisions and to solve problems. The procedures of operations research gave effective assistance during World War II in missions such as deploying radar, searching for enemy submarines, and getting supplies where they were most needed. Following the war, new analytical methods were developed and numerous peacetime applications emerged, leading to the use of operations research in many industries and occupations.

The prevalence of operations research in the Nation's economy reflects the growing complexity of managing large organizations that require the effective use of money, materials, equipment, and people. Operations research analysts help determine better ways to coordinate these elements by applying analytical methods from mathematics, science, and engineering. They solve problems in different ways and propose alternative solutions to management, which then chooses the course of action that best meets the organization's goals. In general, operations research analysts may be concerned with diverse issues such as top-level strategy, planning, forecasting, resource allocation, performance measurement, scheduling, design of production facilities and systems, supply chain management, pricing, transportation and distribution, and analysis of data in large databases.

The duties of the operations research analyst vary according to the structure and management philosophy of the employer or client. Some firms centralize operations research in one department; others use operations research in each division. Operations research analysts also may work closely with senior managers to identify and solve a variety of problems. Some organizations contract operations research services with a consulting firm. Economists, systems analysts, mathematicians, industrial engineers, and others also may apply operations research techniques to address problems in their respective fields. (These occupations are discussed elsewhere in the *Handbook*.)

Regardless of the type or structure of the client organization, operations research in its classical role entails a similar set of procedures in carrying out analysis to support management's quest for

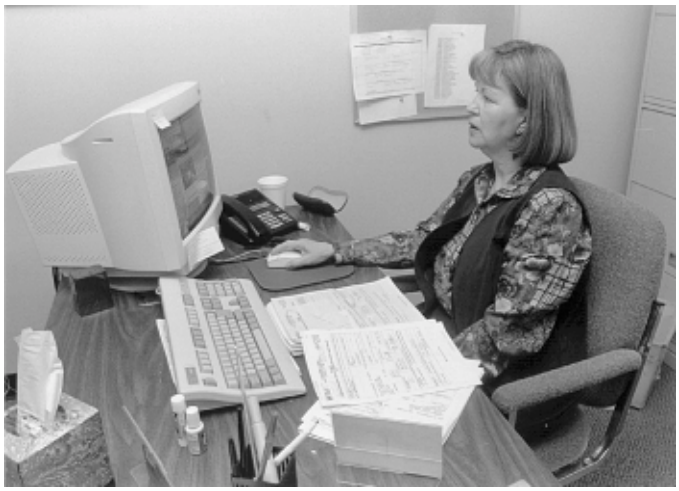
performance improvement. Managers begin the process by describing the symptoms of a problem to the analyst, who then formally defines the problem. For example, an operations research analyst for an auto manufacturer may be asked to determine the best inventory level for each of the parts needed on a production line and to determine the number of windshields to be kept in inventory. Too many windshields would be wasteful and expensive, while too few could result in an unintended halt in production.

Operations research analysts study such problems, then break them into their component parts. Analysts then gather information about each of these parts from a variety of sources. To determine the most efficient amount of inventory to be kept on hand, for example, operations research analysts might talk with engineers about production levels, discuss purchasing arrangements with buyers, and examine data on storage costs provided by the accounting department.

With this information in hand, the analyst is ready to select the most appropriate analytical technique. Analysts could use several techniques—including simulation, linear and nonlinear programming, dynamic programming, queuing and other stochastic-process models, Markov decision processes, econometric methods, data envelopment analysis, neural networks, expert systems, decision analysis, and the analytic hierarchy process. Nearly all of these techniques, however, involve the construction of a mathematical model that attempts to describe the system being studied. The use of models enables the analyst to assign values to the different components, and clarify the relationships between components. These values can be altered to examine what may happen to the system under different circumstances.

In most cases, the computer program developed to solve the model must be modified and run repeatedly to obtain different solutions. A model for airline flight scheduling, for example, might include variables for the cities to be connected, amount of fuel required to fly the routes, projected levels of passenger demand, varying ticket and fuel prices, pilot scheduling, and maintenance costs. By locating the right combination of variable values, the analyst is able to produce the best flight schedule consistent with particular assumptions.

Upon concluding the analysis, the operations research analyst presents to management recommendations based on the results. Additional computer runs to consider different assumptions may be needed before deciding on the final recommendation. Once management reaches a decision, the analyst usually works with others in the organization to ensure the plan's successful implementation.



*Operations research analysts often use computer-generated mathematical models to evaluate and improve an organization's efficiency.*

**Working Conditions**

Operations research analysts generally work regular hours in an office environment. Because they work on projects that are of immediate interest to top management, operations research analysts often are under pressure to meet deadlines and work more than a 40-hour week.

**Employment**

Operations research analysts held about 47,000 jobs in 2000. Major employers include telecommunication companies, air carriers, computer and data processing services firms, financial institutions, insurance carriers, engineering and management services firms, and the Federal Government. Most operations research analysts in the Federal Government work for the U.S. Armed Forces, and many operations research analysts in private industry work directly or indirectly on national defense. About 1 out of 5 analysts work for engineering, management and public relations, and research and testing, agencies that do operations research consulting.

**Training, Other Qualifications, and Advancement**

Employers generally prefer applicants with at least a master's degree in operations research, engineering, business, mathematics, information systems, or management science, coupled with a bachelor's degree in computer science or a quantitative discipline such as economics, mathematics, or statistics. Dual graduate degrees in operations research and computer science are especially attractive to employers. Operations research analysts also must be able to think logically and work well with people, and employers prefer workers with good oral and written communication skills.

In addition to formal education, employers often sponsor training for experienced workers, helping them keep up with new developments in operations research techniques and computer science. Some analysts attend advanced university classes on these subjects at their employer's expense.

Because computers are the most important tools for in-depth analysis, training and experience in programming are required. Operations research analysts typically need to be proficient in database collection and management, programming, and in the development and use of sophisticated software programs.

Beginning analysts usually perform routine work under the supervision of more experienced analysts. As they gain knowledge and experience, they are assigned more complex tasks and given greater autonomy to design models and solve problems. Operations research analysts advance by assuming positions as technical specialists or supervisors. The skills acquired by operations research analysts are useful for higher level management jobs, so experienced analysts may leave the field to assume nontechnical managerial or administrative positions. Operations research analysts with significant experience might become consultants and some may even open their own consulting practice.

**Job Outlook**

Employment of operations research analysts is expected to grow more slowly than the average for all occupations through 2010, because few job openings in this field are expected to have the title *operations research analyst*. Job opportunities in operations research should be good, however, because of interest in improving productivity, effectiveness, and competitiveness, and because of the extensive availability of data, computers, and software. Many jobs in operations research have other titles such as *operations analyst, management analyst, systems analyst, or policy analyst.* Individuals who hold a master's or Ph.D. degree in operations

research, management science, or a closely related field should find good job opportunities as the number of openings generated by employment growth and the need to replace those leaving the occupation is expected to exceed the number of persons graduating with these credentials.

Organizations today face pressure from growing domestic and international competition and must work to make their operations as effective as possible. As a result, businesses will increasingly rely on operations research analysts to optimize profits by improving productivity and reducing costs. As new technology is introduced into the marketplace, operations research analysts will be needed to determine how to utilize the technology in the best way.

Opportunities for operations research analysts exist in almost every industry because of the diversity of applications for their work. However, opportunities should be especially good in highly competitive industries, such as manufacturing, transportation, and telecommunications, and finance. As businesses and government agencies continue to contract out jobs to cut costs, many operations research analysts also will find opportunities as consultants, either working for a consulting firm or setting up their own practice. Opportunities in the military also exist, but will depend on the size of future military budgets. As the military develops new weapons systems and strategies, military leaders will rely on operations research analysts to test and evaluate their accuracy and effectiveness.

**Earnings**

Median annual earnings of operations research analysts were $53,420 in 2000. The middle 50 percent earned between $40,530 and $70,790. The lowest 10 percent had earnings of less than $31,860, while the highest 10 percent earned more than $88,870. In 2000, median annual earnings in the industries employing the largest numbers of operations research analysts were:

| | |
|---|---|
| Computer and data processing services | $65,420 |
| Federal Government | 62,990 |
| Aircraft and parts | 52,960 |
| Engineering and architectural services | 47,480 |

The average annual salary for operations research analysts in the Federal Government in nonsupervisory, supervisory, and managerial positions was $77,730 in 2001.

**Related Occupations**

Operations research analysts apply advanced analytical methods to large, complicated problems. Workers in other occupations that stress advanced analysis include systems analysts, computer scientists, and database administrators; computer programmers; engineers; mathematicians; statisticians; and economists and market and survey researchers. Because its goal is improved organizational effectiveness, operations research also is closely allied to managerial occupations, such as computer and information systems managers, and management analysts.

**Sources of Additional Information**

Information on career opportunities for operations research analysts is available from:

➤ Institute for Operations Research and the Management Sciences, 901 Elkridge Landing Rd., Suite 400, Linthicum, MD 21090. Internet: **http://www.informs.org**

For information on operations research careers in the Armed Forces and U.S. Department of Defense, contact:

➤ Military Operations Research Society, 1703 North Beauregard Street, Suite 450, Alexandria, VA 22311. Internet: **http://www.mors.org**

# Statisticians

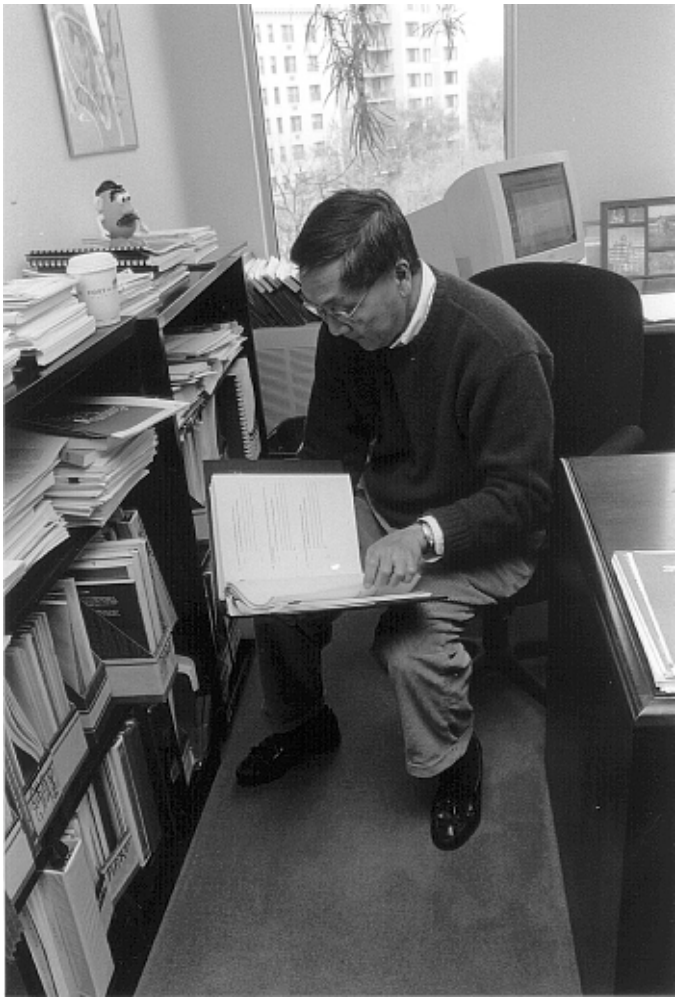
(O*NET 15-2041.00)

**Significant Points**

- Many individuals with degrees in statistics enter jobs that do not have the title statistician.
- A master's degree in statistics or mathematics is the minimum educational requirement for most jobs with this title.
- Although little or no change is expected in employment of statisticians over the 2000-10 period, job opportunities should remain favorable for individuals with statistical degrees.

**Nature of the Work**

Statistics is the scientific application of mathematical principles to the collection, analysis, and presentation of numerical data. Statisticians contribute to scientific inquiry by applying their mathematical knowledge to the design of surveys and experiments; collection, processing, and analysis of data; and interpretation of the results. Statisticians often apply their knowledge of statistical methods to a variety of subject areas, such as biology, economics, engineering,



*Statisticians work in many different fields organizing surveys, collecting data, and analyzing the results.*

medicine, public health, psychology, marketing, education, and sports. Many applications cannot occur without the use of statistical techniques, such as designing experiments to gain Federal approval of a newly manufactured drug.

One technique that is especially useful to statisticians is sampling—obtaining information about a population of people or group of things by surveying a small portion of the total. For example, to determine the size of the audience for particular programs, television-rating services survey only a few thousand families, rather than all viewers. Statisticians decide where and how to gather the data, determine the type and size of the sample group, and develop the survey questionnaire or reporting form. They also prepare instructions for workers who will collect and tabulate the data. Finally, statisticians analyze, interpret, and summarize the data using computer software.

Numerous statisticians also are employed by nearly every government agency. Some government statisticians develop surveys that measure population growth, consumer prices, or unemployment. Other statisticians work for scientific, environmental, and agricultural agencies and may help to determine the amount of pesticides in drinking water, the number of endangered species living in a particular area, or the number of people afflicted with a particular disease. Other statisticians are employed in national defense agencies, determining the accuracy of new weapons and defense strategies.

Because statistical specialists are used in so many work areas, specialists who use statistics often have different professional designations. For example, a person using statistical methods on economic data may have the title econometrician, while statisticians in public health and medicine may hold titles such as biostatistician, biometrician, or epidemiologist.

**Working Conditions**

Statisticians usually work regular hours in comfortable offices. Some statisticians travel to provide advice on research projects, supervise and set up surveys, or gather statistical data. Some may have duties that vary widely, such as designing experiments or performing fieldwork in various communities. Statisticians who work in academia generally have a mix of teaching and research responsibilities.

**Employment**

Statisticians held about 19,000 jobs in 2000. One-fifth of these jobs were in the Federal Government, where statisticians were concentrated in the Departments of Commerce, Agriculture, and Health and Human Services. Most of the remaining jobs were in private industry, especially in the research and testing services and management and public relations industries. In addition, many professionals with a background in statistics were among the 20,000 full-time mathematics faculty in colleges and universities in 2000, according to the American Mathematical Society. (See the statement on teachers—postsecondary elsewhere in the *Handbook.*)

**Training, Other Qualifications, and Advancement**

Although more employment opportunities are becoming available to well-qualified statisticians with bachelor's degrees, a master's degree in statistics or mathematics is usually the minimum educational requirement for most statistician jobs. Research and academic positions in institutions of higher education, for example, require a graduate degree, usually a doctorate, in statistics. Beginning positions in industrial research often require a master's degree combined with several years of experience.

The training required for employment as an entry-level statistician in the Federal Government, however, is a bachelor's degree, including at least 15 semester hours of statistics or a combination of 15 hours of mathematics and statistics, if at least 6 semester hours are in statistics. Qualifying as a mathematical statistician in the Federal Government requires 24 semester hours of mathematics and statistics with a minimum of 6 semester hours in statistics and 12 semester hours in an area of advanced mathematics, such as calculus, differential equations, or vector analysis.

About 80 colleges and universities offered bachelor's degrees in statistics in 2000. Many other schools also offered degrees in mathematics, operations research, and other fields that included a sufficient number of courses in statistics to qualify graduates for some beginning positions in the Federal Government. Required subjects for statistics majors include differential and integral calculus, statistical methods, mathematical modeling, and probability theory. Additional courses that undergraduates should take include linear algebra, design and analysis of experiments, applied multivariate analysis, and mathematical statistics.

In 2000, approximately 110 universities offered a master's degree program in statistics, and about 60 offered a doctoral degree program. Many other schools also offered graduate-level courses in applied statistics for students majoring in biology, business, economics, education, engineering, psychology, and other fields. Acceptance into graduate statistics programs does not require an undergraduate degree in statistics, although good training in mathematics is essential.

Because computers are used extensively for statistical applications, a strong background in computer science is highly recommended. For positions involving quality and productivity improvement, training in engineering or physical science is useful. A background in biological, chemical, or health science is important for positions involving the preparation and testing of pharmaceutical or agricultural products. Courses in economics and business administration are helpful for many jobs in market research, business analysis, and forecasting.

Good communications skills are important for prospective statisticians in industry, where they often need to explain technical matters to persons without statistical expertise. An understanding of business and the economy also is valuable for those who plan to work in private industry.

Beginning statisticians generally are supervised by an experienced statistician. With experience, they may advance to positions with more technical responsibility and, in some cases, supervisory duties. However, opportunities for promotion increase with advanced degrees. Master's and Ph.D. degree holders usually enjoy independence in their work and become qualified to engage in research, develop statistical methods, or, after a number of years of experience in a particular area, become statistical consultants.

**Job Outlook**

Little or no change is expected in employment of statisticians over the 2000-10 period. However, job opportunities should remain favorable for individuals with statistical degrees, although many of these positions will not carry the explicit job title statistician. This is especially true of jobs that involve the analysis and interpretation of data from other disciplines such as economics, biological science, psychology, or engineering. In addition to the limited number of jobs resulting from growth, a number of openings will become available as statisticians retire, transfer to other occupations, or leave the workforce for other reasons.

Among graduates with a bachelor's or master's degree in statistics, those with a strong background in an allied field, such as finance, engineering, or computer science, should have the best prospects of finding jobs related to their field of study. Federal agencies will hire statisticians in many fields, including demography, agriculture, consumer and producer surveys, Social Security,

healthcare, and environmental quality. Competition for entry-level positions in the Federal Government is expected to be strong for those just meeting the minimum qualification standards for statisticians, because the Federal Government is one of the few employers that considers a bachelor's degree to be an adequate entry-level qualification. Those who meet State certification requirements may become high school statistics teachers. (For additional information, see the statement on teachers—preschool, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook.*)

Manufacturing firms will hire statisticians with master's and doctoral degrees for quality control of various products, including pharmaceuticals, motor vehicles, chemicals, and food. For example, pharmaceutical firms employ statisticians to assess the safety and effectiveness of new drugs. To address global product competition, motor vehicle manufacturers will need statisticians to improve the quality of automobiles, trucks, and their components by developing and testing new designs. Statisticians with knowledge of engineering and the physical sciences will find jobs in research and development, working with teams of scientists and engineers to help improve design and production processes to ensure consistent quality of newly developed products. Many statisticians also will find opportunities developing statistical software for computer software manufacturing firms.

Business firms will rely heavily on workers with a background in statistics to forecast sales, analyze business conditions, and help solve management problems in order to maximize profits. In addition, consulting firms increasingly will offer sophisticated statistical services to other businesses. Because of the widespread use of computers in this field, statisticians in all industries should have good computer programming skills and knowledge of statistical software.

**Earnings**

Median annual earnings of statisticians were $51,990 in 2000. The middle 50 percent earned between $37,160 and $69,220. The lowest 10 percent had earnings of less than $28,430, while the highest 10 percent earned more than $86,660.

The average annual salary for statisticians in the Federal Government in nonsupervisory, supervisory, and managerial positions was $68,900 in 2001, while mathematical statisticians averaged $76,530. According to a 2001 survey by the National Association of Colleges and Employers, starting salary offers for mathematics/statistics graduates with a bachelor's degree averaged $46,466 a year.

**Related Occupations**

People in numerous occupations work with statistics. Among these are actuaries; mathematicians; operations research analysts; systems analysts, computer scientists, and database administrators; computer programmers; computer software engineers; engineers; economists and market and survey researchers; financial analysts and personal financial advisors; and life, physical, and social science occupations.

**Sources of Additional Information**

For information about career opportunities in statistics, contact:

➤ American Statistical Association, 1429 Duke St., Alexandria, VA 22314. Internet: **http://www.amstat.org**

For more information on doctoral-level careers and training in mathematics, a field closely related to statistics, contact:

➤ American Mathematical Society, 201 Charles St., Providence, RI 02940. Internet: **http://www.ams.org**

Information on obtaining a statistician position with the Federal Government is available from the Office of Personnel Management (OPM) through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; Federal Relay Service: (800) 877-8339. The first number is not tollfree, and charges may result. Information also is available from the OPM Internet site: **http://www.usajobs.opm.gov**.

## Systems Analysts, Computer Scientists, and Database Administrators

(O*NET 15-1011.00, 15-1051.00, 15-1061.00, 15-1081.00, 15-1099.99)

**Significant Points**

- As computer applications expand, systems analysts, computer scientists, and database administrators are projected to be the among the fastest growing occupations.
- Relevant work experience and a bachelor's degree are prerequisites for many jobs; for more complex jobs, a graduate degree is preferred.

**Nature of the Work**

The rapid spread of computers and information technology has generated a need for highly trained workers to design and develop new hardware and software systems and to incorporate new technologies. These workers—computer systems analysts, computer scientists, and database administrators—include a wide range of computer specialists. Job tasks and occupational titles used to describe these workers evolve rapidly, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers.

*Systems analysts* solve computer problems and enable computer technology to meet individual needs of an organization. They help an organization realize the maximum benefit from its investment in equipment, personnel, and business processes. This process may include planning and developing new computer systems or devising ways to apply existing systems' resources to additional operations. Systems analysts may design new systems, including both hardware and software, or add a new software application to harness more of the computer's power. Most systems analysts work with a specific type of system that varies with the type of organization they work for—for example, business, accounting, or financial systems, or scientific and engineering systems. Some systems analysts also are referred to as *systems developers* or *systems architects*.

Analysts begin an assignment by discussing the systems problem with managers and users to determine its exact nature. They define the goals of the system and divide the solutions into individual steps and separate procedures. Analysts use techniques such as structured analysis, data modeling, information engineering, mathematical model building, sampling, and cost accounting to plan the system. They specify the inputs to be accessed by the system, design the processing steps, and format the output to meet the users' needs. They also may prepare cost-benefit and return-on-investment analyses to help management decide whether implementing the proposed system will be financially feasible.

When a system is accepted, analysts determine what computer hardware and software will be needed to set it up. They coordinate tests and observe initial use of the system to ensure it performs as planned. They prepare specifications, work diagrams, and structure charts for computer programmers to follow and then work with them to "debug," or eliminate errors from, the system. Analysts, who do more in-depth testing of products, may be referred to as

*software quality assurance analysts*. In addition to running tests, these individuals diagnose problems, recommend solutions, and determine if program requirements have been met.

In some organizations, *programmer-analysts* design and update the software that runs a computer. Because they are responsible for both programming and systems analysis, these workers must be proficient in both areas. (A separate statement on computer programmers appears elsewhere in the *Handbook*.) As this becomes more commonplace, these analysts increasingly work with object-oriented programming languages, as well as client/server applications development, and multimedia and Internet technology.

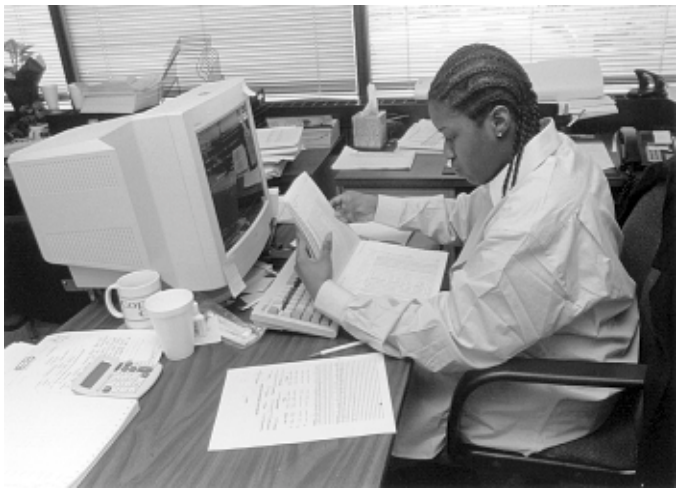
One obstacle associated with expanding computer use is the need for different computer systems to communicate with each other. Because of the importance of maintaining up-to-date information—accounting records, sales figures, or budget projections, for example—systems analysts work on making the computer systems within an organization compatible so that information can be shared. Many systems analysts are involved with "networking," connecting all the computers internally—in an individual office, department, or establishment—or externally, because many organizations now rely on e-mail or the Internet. A primary goal of networking is to allow users to retrieve data and information from a mainframe computer or a server and use it on their machine. Analysts must design the hardware and software to allow free exchange of data, custom applications, and the computer power to process it all.

Networks come in many variations and *network systems and data communications analysts* analyze, design, test, and evaluate systems such as local area networks (LAN), wide area networks (WAN), Internet, Intranets, and other data communications systems. These analysts perform network modeling, analysis and planning; they also may research related products and make necessary hardware and software recommendations. *Telecommunications specialists* focus on the interaction between computer and communications equipment.

The growth of the Internet and expansion of the World Wide Web, the graphical portion of the Internet, have generated a variety of occupations related to design, development, and maintenance of Web sites and their servers. For example, *webmasters* are responsible for all technical aspects of a website, including performance issues such as speed of access, and for approving site content. *Internet developers* or w*eb developers*, also called *web designers*, are responsible for day-to-day site design and creation.

*Computer scientists* work as theorists, researchers, or inventors. Their jobs are distinguished by the higher level of theoretical expertise and innovation they apply to complex problems and the creation or application of new technology. Those employed by academic institutions work in areas ranging from complexity theory, to hardware, to programming language design. Some work on multidisciplinary projects, such as developing and advancing uses of virtual reality, in human-computer interaction, or in robotics. Their counterparts in private industry work in areas such as applying theory, developing specialized languages or information technologies, or designing programming tools, knowledge-based systems, or even computer games.

With the Internet and electronic business creating tremendous volumes of data, there is growing need to be able to store, manage, and extract data effectively. *Database administrators* work with database management systems software and determine ways to organize and store data. They determine user requirements, set up computer databases, and test and coordinate changes. It is the responsibility of an organization's database administrator to ensure performance, understand the platform the database runs on, and add new users. Because they also may design and implement system security, database administrators often plan and coordinate security measures. With the volume of sensitive data generated every second growing rapidly, data integrity, backup, and keeping databases secure have become an increasingly important aspect of the job for database administrators.



*Systems analysts ensure that organizations get the maximum benefit from available technology.*

**Working Conditions**

Systems analysts, computer scientists, and database administrators normally work in offices or laboratories in comfortable surroundings. They usually work about 40 hours a week—the same as many other professional or office workers. However, evening or weekend work may be necessary to meet deadlines or solve specific problems. Given the technology available today, telecommuting is common for computer professionals. As networks expand, more work can be done from remote locations using modems, laptops, electronic mail, and the Internet.

Like other workers who spend long periods in front of a computer terminal typing on a keyboard, they are susceptible to eye strain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome or cumulative trauma disorder.

**Employment**

Systems analysts, computer scientists, and database administrators held about 887,000 jobs in 2000, including about 71,000 who were self-employed. Employment was distributed among the following detailed occupations:

| | |
|---|---|
| Computer system analysts | 431,000 |
| Network systems and data communications analysts | 119,000 |
| Database administrators | 106,000 |
| Computer and information scientists, research | 28,000 |
| All other computer specialists | 203,000 |

Although they are increasingly employed in every sector of the economy, the greatest concentration of these workers is in the computer and data processing services industry. Firms in this industry provide nearly every service related to commercial computer use on a contract basis. Services include systems integration, networking, and reengineering; data processing and preparation; information retrieval, including on-line databases and Internet; onsite computer facilities management; development and management of databases; and a variety of specialized consulting. Many systems analysts, computer scientists, and database administrators work for other employers, such as government, manufacturers of computer and related electronic equipment, insurance companies, financial institutions, and universities.

A growing number of computer specialists, such as systems analysts and network and data communications analysts, are employed on a temporary or contract basis—many of whom are self-employed, working independently as contractors or self-employed consultants. For example, a company installing a new computer system may need the services of several systems analysts just to get the system running. Because not all of them would be needed once the system is functioning, the company might contract with systems analysts or a temporary help agency or consulting firm. Such jobs may last from several months up to 2 years or more. This growing practice enables companies to bring in people with the exact skills they need to complete a particular project, rather than having to spend time or money training or retraining existing workers. Often, experienced consultants then train a company's in-house staff as a project develops.

**Training, Other Qualifications, and Advancement**

Rapidly changing technology means an increasing level of skill and education demanded by employers. Companies are looking for professionals with a broader background and range of skills, including not only technical knowledge, but also communication and other interpersonal skills. This shift from requiring workers to possess solely sound technical knowledge emphasizes workers who can handle various responsibilities. While there is no universally accepted way to prepare for a job as a systems analyst, computer scientist, or database administrator, most employers place a premium on some formal college education. A bachelor's degree is a prerequisite for many jobs; however, some jobs may require only a 2-year degree. Relevant work experience also is very important. For more technically complex jobs, persons with graduate degrees are preferred.

For systems analyst, programmer-analyst, as well as database administrator positions, many employers seek applicants who have a bachelor's degree in computer science, information science, or management information systems (MIS). MIS programs usually are part of the business school or college. These programs differ considerably from computer science programs, emphasizing business and management-oriented coursework and business computing courses. Many employers increasingly seek individuals with a master's degree in business administration (MBA) with a concentration in information systems, as more firms move their business to the Internet. For some networks systems and data communication analysts, such as webmasters, an associate degree or certificate generally is sufficient, although more advanced positions might require a computer-related bachelor's degree. For computer and information scientists, a doctoral degree generally is required due to the highly technical nature of their work.

Despite the preference towards technical degrees, persons with degrees in a variety of majors find employment in these computer occupations. The level of education and type of training employers require depend on their needs. One factor affecting these needs is changes in technology. As demonstrated by the current demand for workers with skills related to the Internet, employers often scramble to find workers capable of implementing "hot" new technologies. Another factor driving employers' needs is the time frame in which a project must be completed.

Most community colleges and many independent technical institutes and proprietary schools offer an associate degree in computer science or a related information technology field. Many of these programs may be more geared toward meeting the needs of local businesses and are more occupation-specific than those designed for a 4-year degree. Some jobs may be better suited to the level of training these programs offer. Employers usually look for people who have broad knowledge and experience related to computer systems and technologies, strong problem-solving and analytical skills, and good interpersonal skills. Courses in computer science or systems design offer good preparation for a job in these computer occupations. For jobs in a business environment, employers usually want systems analysts to have business management or closely related skills, while a background in the physical sciences, applied mathematics, or engineering is preferred for work in scientifically oriented organizations. Art or graphic design skills may be desirable for webmasters or Web developers.

Jobseekers can enhance their employment opportunities by participating in internship or co-op programs offered through their schools. Because many people develop advanced computer skills in one occupation and then transfer those skills into a computer occupation, a related background in the industry in which the job is located, such as financial services, banking, or accounting, can be important. Others have taken computer science courses to supplement their study in fields such as accounting, inventory control, or other business areas. For example, a financial analyst proficient in computers might become a systems analyst or computer support specialist in financial systems development, while a computer programmer might move into a systems analyst job.

Systems analysts, computer scientists, and database administrators must be able to think logically and have good communication skills. They often deal with a number of tasks simultaneously; the ability to concentrate and pay close attention to detail is important. Although these computer specialists sometimes work independently, they often work in teams on large projects. They must be able to communicate effectively with computer personnel, such as programmers and managers, as well as with users or other staff who may have no technical computer background.

Computer scientists employed in private industry may advance into managerial or project leadership positions. Those employed in academic institutions can become heads of research departments or published authorities in their field. Systems analysts may be promoted to senior or lead systems analyst. Those who show leadership ability also can become project managers or advance into management positions such as manager of information systems or chief information officer. Database administrators also may advance into managerial positions such as chief technology officer, based on their experience managing data and enforcing security. Computer specialists with work experience and considerable expertise in a particular subject area or application may find lucrative opportunities as independent consultants or choose to start their own computer consulting firms.

Technological advances come so rapidly in the computer field that continuous study is necessary to keep skills up to date. Employers, hardware and software vendors, colleges and universities, and private training institutions offer continuing education. Additional training may come from professional development seminars offered by professional computing societies.

Technical or professional certification is a way to demonstrate a level of competency or quality in a particular field. Product vendors or software firms also offer certification and may require professionals who work with their products to be certified. Many employers regard these certifications as the industry standard. For example, one method of acquiring enough knowledge to get a job as a database administrator is to become certified in a specific type of database management. Voluntary certification also is available through other organizations. Professional certification may provide a job seeker a competitive advantage.

**Job Outlook**

Systems analysts, computers scientists, and database administrators are expected to be the among the fastest growing occupations through

2010. Employment of these computer specialists is expected to increase much faster than the average for all occupations as organizations continue to adopt and integrate increasingly sophisticated technologies. Growth will be driven by very rapid growth in computer and data processing services, which is projected to be the fastest growing industry in the U.S. economy. In addition, many job openings will arise annually from the need to replace workers who move into managerial positions or other occupations or who leave the labor force.

The demand for networking to facilitate the sharing of information, the expansion of client/server environments, and the need for computer specialists to use their knowledge and skills in a problem-solving capacity will be major factors in the rising demand for systems analysts, computer scientists, and database administrators. Moreover, falling prices of computer hardware and software should continue to induce more businesses to expand computerized operations and integrate new technologies. In order to maintain a competitive edge and operate more efficiently, firms will continue to demand computer specialists who are knowledgeable about the latest technologies and are able to apply them to meet the needs of businesses.

Increasingly, more sophisticated and complex technology is being implemented across all organizations, which should fuel the demand for these computer occupations. There is a growing demand for system analysts to help firms maximize their efficiency using available technology. The explosive growth in electronic commerce—doing business on the Internet—and the continuing need to build and maintain databases that store critical information on customers, inventory, and projects is fueling demand for database administrators familiar with the latest technology.

The development of new technologies usually leads to demand for various workers. The expanding integration of Internet technologies by businesses, for example, has resulted in a growing need for specialists who can develop and support Internet and intranet applications. The growth of electronic commerce means more establishments use the Internet to conduct their business online. This translates into a need for information technology professionals who can help organizations use technology to communicate with employees, clients, and consumers. Explosive growth in these areas also is expected to fuel demand for specialists knowledgeable about network, data, and communications security.

As technology becomes more sophisticated and complex, employers demand a higher level of skill and expertise. Individuals with an advanced degree in computer science, computer engineering, or an MBA with a concentration in information systems should enjoy very favorable employment prospects. College graduates with a bachelor's degree in computer science, computer engineering, information science, or management information systems also should enjoy favorable prospects for employment, particularly if they have supplemented their formal education with practical experience. Because employers continue to seek computer specialists who can combine strong technical skills with good interpersonal and business skills, graduates with non-computer science degrees but who have had courses in computer programming, systems analysis, and other information technology areas, also should continue to find jobs in these computer fields. In fact, individuals with the right experience and training can work in these computer occupations regardless of their college major or level of formal education.

**Earnings**

Median annual earnings of computer systems analysts were $59,330 in 2000. The middle 50 percent earned between $46,980 and $73,210 a year. The lowest 10 percent earned less than $37,460, and the highest 10 percent earned more than $89,040. Median annual earnings in the industries employing the largest numbers of computer systems analysts in 2000 were:

| | |
|---|---|
| Computer and data processing services | $64,110 |
| Professional and commercial equipment | 63,530 |
| Federal Government | 59,470 |
| Local government | 52,490 |
| State government | 51,230 |

Median annual earnings of database administrators were $51,990 in 2000. The middle 50 percent earned between $38,210 and $71,440. The lowest 10 percent earned less than $29,400, and the highest 10 percent earned more than $89,320. In 2000, median annual earnings of database administrators employed in computer and data processing services were $63,710, and in telephone communication, $52,230.

Median annual earnings of network systems and data communication analysts were $54,510 in 2000. The middle 50 percent earned between $42,310 and $69,970. The lowest 10 percent earned less than $33,360, and the highest 10 percent earned more than $88,620. Median annual earnings in the industries employing the largest numbers of network systems and data communications analysts in 2000 were:

| | |
|---|---|
| Management and public relations | $60,260 |
| Commercial banks | 59,910 |
| Computer and data processing services | 59,160 |
| Telephone communications | 51,780 |
| State government | 42,000 |

Median annual earnings of computer and information scientists, research, were $70,590 in 2000. The middle 50 percent earned between $54,700 and $89,990. The lowest 10 percent earned less than $41,390, and the highest 10 percent earned more than $113,510. Median annual earnings of computer and information scientists employed in computer and data processing services in 2000 were $71,940.

Median annual earnings of all other computer specialists were $50,590 in 2000. Median annual earnings of all other computer specialists employed in computer and data processing services were $51,970, and in professional and commercial equipment, $80,270 in 2000.

According to the National Association of Colleges and Employers, starting offers for graduates with a master's degree in computer science averaged $61,453 in 2001. Starting offers for graduates with a bachelor's degree in computer science averaged $52,723; in computer programming, $48,602; in computer systems analysis, $45,643; in information sciences and systems, $45,182; and in management information systems, $45,585.

According to Robert Half International, starting salaries in 2001 ranged from $72,500 to $105,750 for database administrators. Salaries for Internet-related occupations ranged from $58,000 to $82,500 for webmasters and $56,250 to $76,750 for Internet/Intranet developers.

**Related Occupations**

Other workers who use logic and creativity to solve business and technical problems are computer programmers, computer software engineers, computer and information systems managers, financial analysts and personal financial advisors, urban and regional planners, engineers, mathematicians, statisticians, operations research analysts, management analysts, and actuaries.

**Sources of Additional Information**

Further information about computer careers is available from:

➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**

➤ IEEE Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

Information about becoming a Certified Computing Professional is available from:

➤ Institute for Certification of Computing Professionals (ICCP), 2350 East Devon Ave., Suite 115, Des Plaines, IL 60018. Internet: **http://www.iccp.org**